Model 300

INSTRUCTIONS FOR

AC ELECTRONIC VOLTMETER

MODEL 300

BALLANTINE LABORATORIES, INC.
BOONTON, NEW JERSEY

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CONTENTS

	Page
Specifications	2
General	3
General Circuit Description	3
Operation	3
Input Impedance	4
Overload Characteristics	4
Effect of Wave Form	4
Measurement of Line Frequency Voltages	5
Measurement of Voltages Over 100 Volts	5
Measurement of Voltages Below One Millivolt	6
Measurement of Power Levels	6
Use As An Amplifier	7
Provision of DC Output	7
Use As A Microammeter-Ammeter	8
Measurement of Direct Voltages	8
Scale Range Adjustment	8
Servicing	9
Special Versions of the Model 300	10

REFERENCE LIST OF PARTS

REFER TO MODEL 300 SCHEMATIC DIAGRAM MC-107M

B.L. Part #	Circuit Symbol	RESISTORS	Manufacturer
1005	R1	3 megohms, Type EB, 10%	Allen-Bradley
1030	R2	51,000 ohms, Type EB, 5%	Allen-Bradley
1628	R4	450,000 ohms, Type P51, ½%	Shallcross
1629	R5	45,000 ohms, Type P51, ½%	Shallcross
1630	R6	4,500 ohms, Type P12, ½%	Shallcross
1631	R7	450 ohms, Type P12, ½%	Shallcross
1632	R8	50 ohms, Type P12, ½%	Shallcross
1054	R9	2,000 ohms, Type EB, 5%	Allen-Bradley
1751	R10	4.3 ohms, Special	Ballantine
1040	R11	20,000 ohms, Type EB, 5%	Allen-Bradley
1864	R12	50,000 ohms, Type M161, 1%	Mepco
1020	R13	300,000 ohms, Type EB, 5%	Allen-Bradley
1040	R14	20,000 ohms, Type EB, 5%	Allen-Bradley
1054	R15	2,000 ohms, Type EB, 5%	Allen-Bradley
1026	R16	100,000 ohms, Type EB, 5%	Allen-Bradley
1032	R17	47,000 ohms, Type EB, 5%	Allen-Bradley
1015	R18	470,000 ohms, Type EB, 5%	Allen-Bradley
1040	R19	20,000 ohms, Type EB, 5%	Allen-Bradley
1062	R20	390 ohms, Type EB, 5%	Allen-Bradley
1032	R21	47,000 ohms, Type EB, 5%	Allen-Bradley
1633	R22	38,000 ohms, Type P34, 1%	Shallcross
1864	R23	50,000 ohms, Type M161, 1%	Mepco
1054	**R24	2,000 ohms, Type EB, 5%	Allen-Bradley
1026	R25	100,000 ohms, Type EB, 5%	Allen-Bradley
1007	R26	2,000,000 ohms, Type EB, 5%	Allen-Bradley
1904	R27	20,000 ohms, Type Q Volume Control	I.R.C.
1912	**R28	25,000 ohms, Type Q Volume Control	I.R.C.
1578	R29	4,700 ohms, Type BW-2, 5%	I.R.C.
1626	R30	27,000 ohms, Type 28E, 5%	Sprague
1578	R31	4,700 ohms, Type BW-2, 5%	I.R.C.
1256	R32	20,000 ohms, Type GB, 5%	Allen-Bradley
1252	R33	62,000 ohms, Type GB, 5%	Allen-Bradley
1066	R34	160 ohms, Type EB, 5%	Allen-Bradley
1024	R35	150,000 ohms, Type EB, 5%	Allen-Bradley
1007	**R36	2,000,000 ohms, Type EB, 5%	Allen-Bradley
1063	R37	300 ohms, Type EB, 5%	Allen-Bradley

** The values of these items are determined during the calibration of the instrument and may differ from the value listed.

REFERENCE LIST OF PARTS

REFER TO MODEL 300 SCHEMATIC DIAGRAM MC-107M

B.L. Part #	Circuit Symbol	CONDENSERS	Manufacturer
2143	C1	.1 μF, 400 volts, Type 109P10494	Sprague
2428	C2	25 pF, maximum, Type 823-Z	Centralab
2506	C3	4.7 pF, Type GA-6	Stackpole
2431	C4	3-12 pF, maximum, Type 503-27	Erie
2218	**C5	.015 μF, mica +0 -10%, Type CM35B153J	Arco
2210	C6	.001 μF, mica, 5%, Type CM30	Arco
2407	C7	550-1600 pF, No. X309	El-Menco
2402	C8	65-340 pF, No. X303	El-Menco
2407	C9	550-1600 pF, No. X309	El-Menco
2201	C10	2 pF, Type CM15C-020-M	Arco
2055	C11	25 μF, 25 volts, Type DPE	Sprague
2053	C12	20 μF, 250 volts, Type DEE	Sprague
2053	C13	20 μF, 250 volts, Type DEE	Sprague
2142	C14	.1 μF, 200 volts, Type 109P10492	Sprague
2055	C15	25 μF, 25 volts, Type DPE	Sprague
2053	C16	20 μF, 250 volts, Type DEE	Sprague
2053	C17	20 μF, 250 volts, Type DEE	Sprague
2143	C18	.1 μF, 400 volts, Type 109P10494	Sprague
2055	C19	25 μF, 25 volts, Type DPE	Sprague
2053	C20	20 μF, 250 volts, Type DEE	Sprague
2306	C21	.5 μF, 400 volts, PUP	Cornell-Dubilier
2515	**C22	5 pF, Type GP1K	Erie
2055	C23	25 μF, 25 volts, Type DPE	Sprague
2160	C24	2 μF, 600 volts, Type 7160-2	Sangamo
2051	C25	8 μF, 450 volts, Type DEE	Sprague
2051	C26	8 μF, 450 volts, Type DEE	Sprague

TUBES

3102	V-1	- One Type 6J7 or 1620, RCA or equal
3103	V-2	- One Type 6SJ7, RCA or equal
3103	V-3	
3108	V-4	- One Type 6AL5, RCA or equal
3100	V-5	- One Type 6X5, RCA or equal
3106	V-6	- One Type OA2, RCA or equal
3451		- One pilot light, 6.3 volts, .150 amp, bayonet

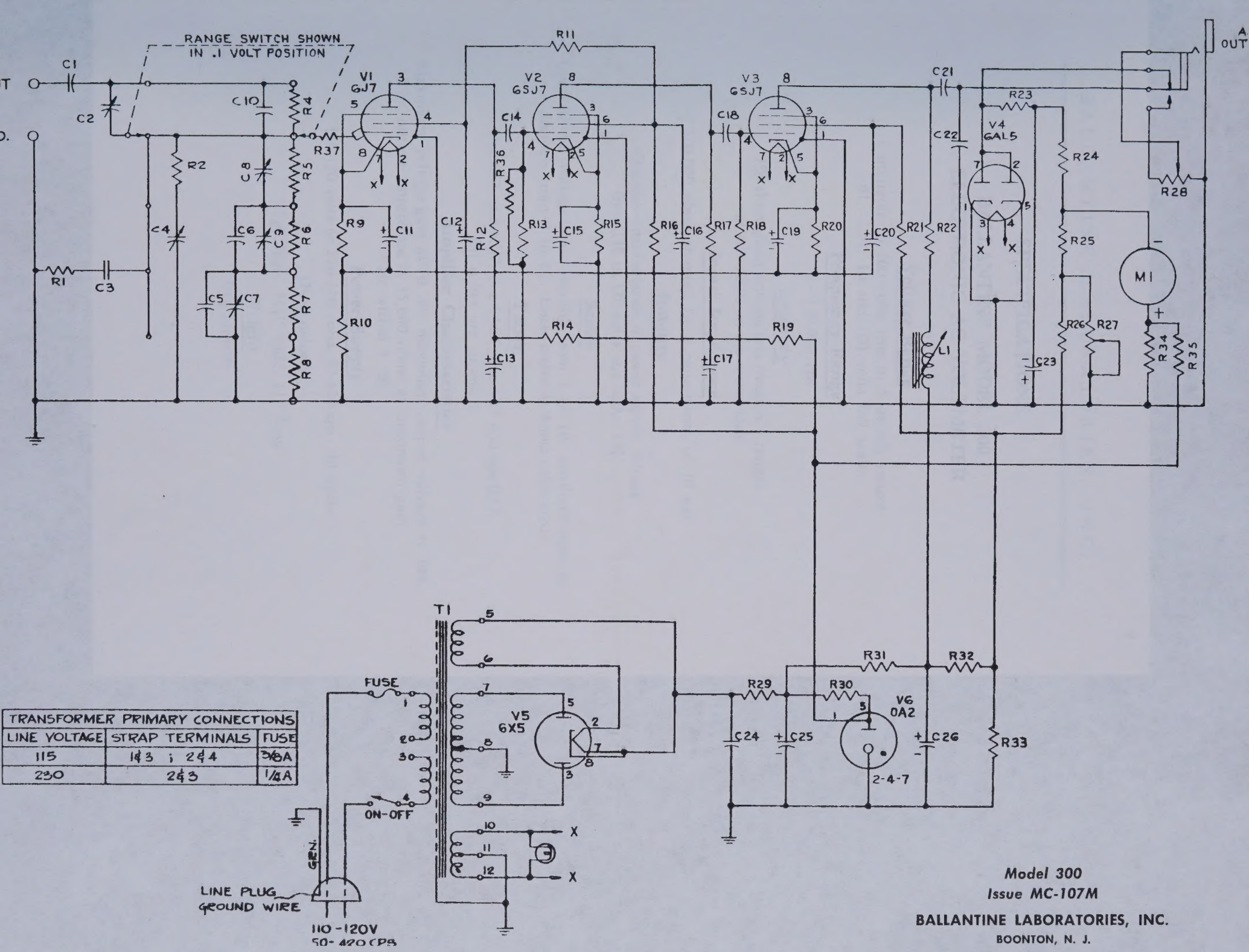
** The values of these items are determined during the calibration of the instrument and may differ from the value listed.

METER

3151	M-1	- Special type obtained from Ballantine Laboratories, Inc. only
3409	Fuse	- 3/8 ampere, Type 8-AG, Littelfuse Inc., Type 362.375 or equal

TRANSFORMER

3027	T-1	- Type A-326F below Serial #21157, Ballantine Laboratories, Inc.
3040		- Type MB-521A above Serial #21157, Ballantine Laboratories, Inc.
3003	L-1	- Peaking Coil, Ballantine Laboratories, Inc.



TRANSFORMER PRIMARY CONNECTIONS		
LINE VOLTAGE	STRAP TERMINALS	FUSE
115	1&3 ; 2&4	3/8A
230	2&3	1/4A

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Issue MC-107M

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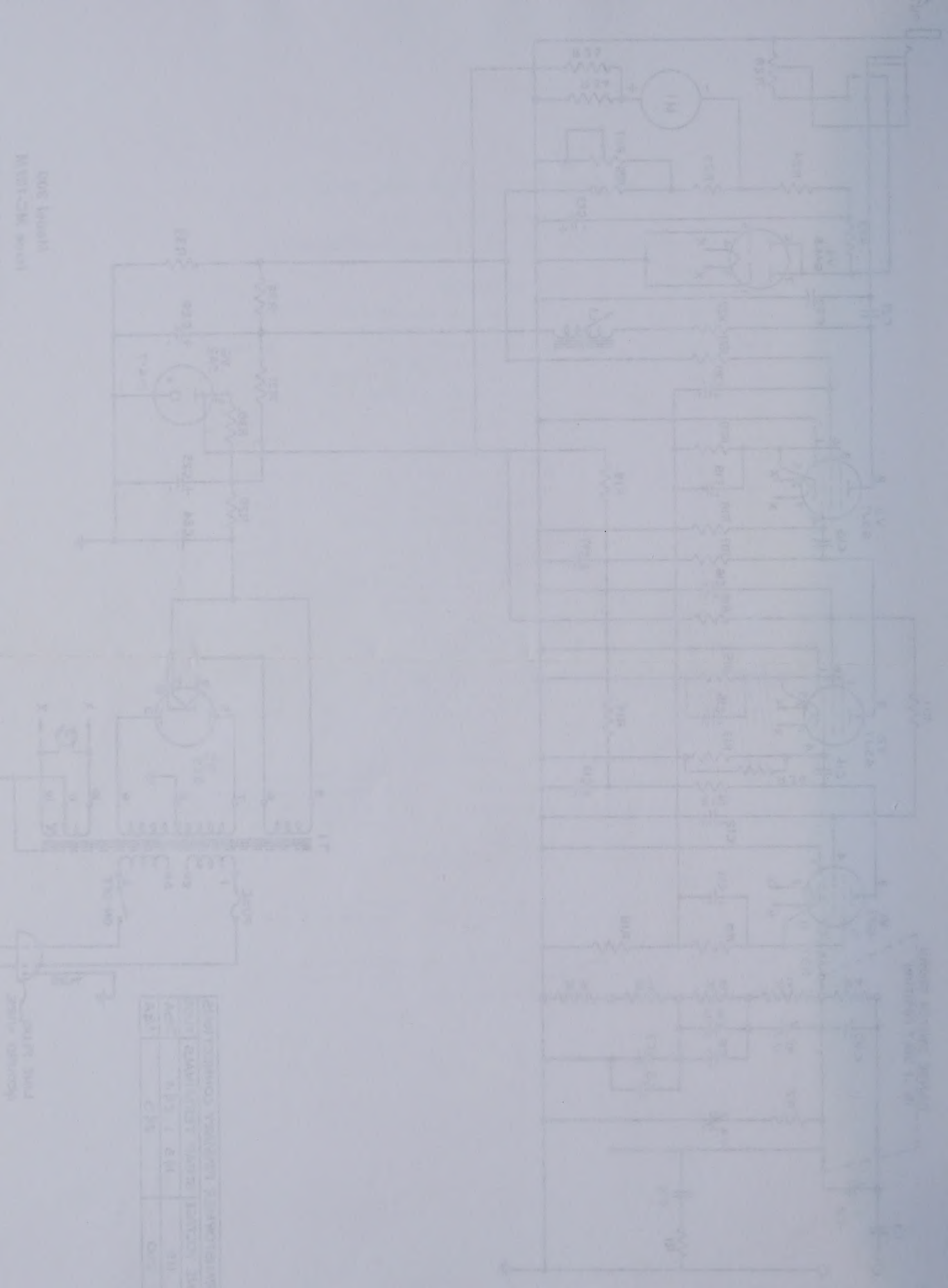

SPECIFICATIONS

BALLANTINE MODEL 300
ELECTRONIC AC VOLTMETER

Voltage Range

1 millivolt to 100 volts rms in 5 decade ranges
(.01, .1, 1, 10 and 100 volts full scale)

Frequency Range

10—150,000 cps

Accuracy

2% throughout voltage and frequency ranges.
at any point on the meter scale

Input Impedance

500,000 ohms shunted by a capacitance of 30 $\mu\mu$f

Stability

Changes with variation in power supply voltage
from 110 to 120 volts, are below 1%

Scales

Logarithmic voltage scale reading from 1 to 10; auxiliary scale in decibels from 0 to 20. Each meter is hand calibrated.

Tubes

One 6J7, two 6SJ7, one 6AL5, one 6X5 and one 0A2.
All tubes are supplied.

Amplifier Characteristics

Maximum voltage gain of 70 db; maximum output voltage is 30v, output impedance is 15,000 ohms at maximum gain.
Flat within 1 db

Power Supply

110-120 volts or 220-240 volts, 50-420 cps. 30 watts.

Dimensions

4½" high, 5¾" wide, 11" long

Weight

9½ pounds

INSTRUCTIONS FOR

AC ELECTRONIC VOLTMETER

MODEL 300

GENERAL—This voltmeter is designed to measure sinusoidal voltages from 1 millivolt to 100 volts over a frequency range from 10 to 150,000 cps. It operates from a 110-120 volt 50-420-cycle power supply. 230-volt models are also available on special order as are other special versions having the characteristics described on page 10.

By means of a five decade range switch, the entire voltage range is indicated on a single logarithmic voltage scale reading from 1 to 10. The indicating meter also has a uniform decibel scale, numbered from 0 to 20 decibels. The zero of the decibel scale is arbitrarily arranged for maximum usefulness so as to correspond to 1 on the voltage scale

Its accuracy is 2% from 10 to 150,000 cycles. Since the scale is logarithmic **the accuracy is the same at any point on the scale.**

An ac output jack permits the amplifier section of the voltmeter to be used as a flat high gain amplifier with an adjustable gain from 0 to 70 db.

GENERAL CIRCUIT DESCRIPTION—The voltmeter employs a resistance-capacitance decade attenuator, a high-gain three stage negative feedback stabilized amplifier, a rectifier and a logarithmic indicating meter responding to the average values of the voltage wave but calibrated in rms values of a sine wave. Wire-wound resistors are used in the attenuator so as to insure a degree of stability otherwise unobtainable. The amplifier has sufficient feedback to render the indications of the voltmeter substantially independent of changes in line voltage, tubes, and other circuit components.

OPERATION—The voltmeter is supplied with tubes and is ready to operate as received. It is merely necessary to connect it to the ac power source and turn on the switch marked "ON-OFF." A pilot light is provided to indicate when power is on. The input terminal marked "GND" is connected to the case of the instrument and therefore, whenever possible, it should be connected to the ground of the circuit in which a voltage is being measured.

INPUT IMPEDANCE — The input impedance of the voltmeter is 500,000 ohms shunted by a capacitance of 30 $\mu\mu$f.

If a higher input impedance is desired and if it is not necessary to read less than 10 millivolts, the input impedance may be increased to 5 megohms shunted by 8 $\mu\mu$f by using the Ballantine Model 1300A Multiplier ahead of the voltmeter. If it is not necessary to read less than 100 millivolts, the input impedance may be increased to 40 megohms shunted by 3 $\mu\mu$f by using the Ballantine Model 1300B Multiplier ahead of the voltmeter.

Any direct current component of the wave under measurement is isolated from the voltmeter by means of a series input blocking capacitor of 400 volts rating. If dc voltages higher than this are applied an auxiliary protective network should be provided consisting of a 1 μf capacitor in series with the connection to the high potential input terminal and a 1 megohm resistor in shunt with the input terminals. An example of the use of such a network would be the measurement of commutator ripple on a 600-volt dynamotor.

OVERLOAD CHARACTERISTICS — The amplifier circuits are designed to saturate promptly when the voltage exceeds the full scale indication of the meter, thus protecting the indicating meter. This is a considerable advantage over other types of meters which may be seriously damaged by overloads such as the Model 300 Voltmeter will stand. The maximum voltage which can be safely tolerated on each range for an indefinite period is as follows:

Range	Max. Voltage	Overload Ratio
.001 - .01	2	200
.01 - .1	20	200
.1 - 1	200	200
1 - 10	400	40
10 - 100	400	4

EFFECT OF WAVE FORM — The indications of the voltmeter are proportional to the average value of the ac wave under measurement. Since, however, it is primarily intended to measure sinusoidal waves its calibration is in terms of the rms value of a sinusoidal wave. Since electronic voltmeters of the input diode rectifier

type respond to the peak values of a wave, the readings of such meters and the present voltmeter will not necessarily agree when harmonics are present. The amount of the discrepancy will depend on the number and magnitude of the harmonics present as well as their phase relationship with respect to the fundamental. In all cases however, the departure of the readings from true rms values due to the presence of harmonics will be considerably less with an average responding meter such as the Model 300 than with a peak responding meter. For example in the case of a third harmonic whose amplitude is 20% of the fundamental the maximum error of a peak responding meter may be as much as 20% whereas the maximum error of an average responding meter such as the Model 300 will never exceed 6.7%.

Inasmuch as the Model 300 Voltmeter responds to the average value of the ac wave, "turn-over" discrepancies occasioned by any lack of symmetry of the wave such as are experienced in half-wave peak reading instruments are eliminated, provided the crest factor of the wave does not exceed 2 when readings are being made at full scale. For lower readings the crest factor limit is increased in inverse proportion to the ratio of the reading and full scale deflection.

MEASUREMENT OF LINE FREQUENCY VOLTAGES— Even though the amount of residual hum in the voltmeter is extremely small, it may introduce slight inaccuracies (1 to 2%) in the readings at the lower end of the scale when the voltmeter is used to measure voltages having exactly the same frequency as that of the power supply mains. These inaccuracies may be minimized by making two measurements, one with the power plug in normal polarity and the other with the power plug reversed. The mean of these readings will represent the true value of the voltage being measured.

MEASUREMENT OF VOLTAGES ABOVE 100 VOLTS— Multipliers are available from Ballantine Laboratories, Inc., to extend the range of the voltmeter to voltages above 100. The Model 1300A Multiplier extends the range by a factor of 10 up to 1,000 volts maximum. This has an input impedance of 5 megohms shunted by 8 $\mu\mu$f. The Model 1300B Multiplier extends the range by a factor of 100 to 10,000 volts and has an input impedance of 40 megohms shunted by 3 $\mu\mu$f.

These multipliers cover the same frequency range as the Model 300 Voltmeter.

MEASUREMENT OF VOLTAGES BELOW ONE MILLIVOLT—When voltages below one millivolt are to be measured we recommend the use of the Ballantine battery operated Decade Amplifier, Model 220-B. This provides gains of exactly ten times or one hundred times and when connected ahead of the Model 300 Voltmeter permits measurements down to values as low as 20 microvolts in the frequency range 10 cps to 150 kc.

MEASUREMENT OF POWER LEVELS — In view of the many different applications for Ballantine Voltmeters and the prevailing differences in power reference levels, it was felt inadvisable to relate the db scale to a particular level in the standard version of the Model 300. Accordingly, in the interest of clarity and generality, the 0 of the db scale has been set arbitrarily at 1 on the voltage scale, and 20 db, therefor, corresponds to 10 on the voltage scale (A special version, Model 300-S/5, is available however with the db scale arranged for zero at 1 mw/600Ω).

The most frequently used power references at which a level of zero decibels is arbitrarily set are:

(1) 1 mw/600 Ω { 1 milliwatt of power corresponding to 0.775 volts across a pure resistance of 600 ohms.

(2) 6 mw/600 Ω { 6 milliwatts of power corresponding to 1.897 volts across a pure resistance of 600 ohms.

(3) 6 mw/500 Ω { 6 milliwatts of power corresponding to 1.732 volts across a pure resistance of 500 ohms.

The following table enables a ready conversion from the db reading of the Ballantine Scale to the actual zero db power level for any of the reference levels above including zero db corresponding to 1 volt.

If power reference levels other than those above are involved the Ballantine Laboratories, Inc., DB Slide Rule will be found very useful in the corresponding decibel level determinations. The slide rules are available free of charge on application to the Company.

MODEL 300 RANGE SETTING	DB TO BE ADDED TO OR SUBTRACTED FROM THE DB READING ON THE BALLANTINE DB SCALE IN ORDER TO CONVERT TO THE DESIRED ZERO REFERENCE LEVEL			
Volts Full Scale	Zero Level = 1mw-600 ohm	Zero Level = 6mw-600 ohm	Zero Level = 6mw-500 ohm	Zero Level = 1 volt
0.01	−57.8	−65.6	−64.8	−60
0.1	−37.8	−45.6	−44.8	−40
1.0	−17.8	−25.6	−24.8	−20
10.0	+ 2.2	− 5.6	− 4.8	0
100.0	+22.2	+14.4	+15.2	+20

USE AS AN AMPLIFIER — Inserting a standard tip and sleeve telephone plug into the output jack marked "AC OUTPUT" automatically disconnects the rectifier and the indicating meter and permits the amplifier section of the voltmeter to be used as a stable amplifier with a maximum gain of 70 db. The gain is adjustable in steps of 20 db by means of the range switch and finer adjustments in gain may be made by means of the knob marked "AC OUTPUT CONTROL." When the latter is set for maximum gain the output impedance of the amplifier is approximately 15,000 ohms. The amplifier will provide uniform voltage amplification within 1 db over the range from 10 to 150,000 cps when loaded by a resistance of not less than one megohm and a capacitance (including that of the telephone plug) of not more than 30 $\mu\mu$f. The hum and noise level present at the output jack when the instrument is used as an amplifier is less than 50 millivolts which is 55 db down from its maximum undistorted output voltage level of 30 volts. This hum and noise level is equivalent to less than 16 microvolts when referred to the input.

PROVISION OF DC OUTPUT — A useful and compact accessory, the Model 2300 DC Output Adapter, is available from Ballantine Laboratories and is designed to plug into the "AC OUTPUT" jack of the voltmeter, thus allowing it to drive external strip-chart recorders, remote meters, or any other external device requiring up to 2 milli-

amperes of DC for normal operation. Such loads will then respond uniformly to any voltage covered by the voltmeter over a frequency range of 40 to 150,000 cps.

Provision is made for calibrating the DC output of the Model 2300 Adapter against the voltmeter readings by means of an accessible control.

The output binding posts are isolated from ground so as to leave the user the option of grounding either the positive or negative leg or of leaving both terminals floating.

USE AS A MICROAMMETER-AMMETER—By using Ballantine Series 600 Precision Shunt Resistors in conjunction with this voltmeter alternating currents from 1 microampere to 1 ampere can be measured over the frequency range 10 to 150,000 cps, and to 10 amperes over the range 10 to 20,000 cps.

MEASUREMENT OF DIRECT VOLTAGES — Ballantine Laboratories manufactures an instrument known as the Model 700 Precision Sensitive Inverter which, although it has multifarious applications elsewhere, may be combined with the Model 300 Voltmeter to measure direct potentials from 100 volts down to as low as 10 microvolts with an input resistance of 50 megohms down to 100 millivolts and 10 megohms below.

Among the many features of the Model 700 Inverter are means for polarity sensing, extremely small zero drift, and a built-in device for calibrating the Inverter-Voltmeter combination so that a high degree of accuracy is realized under the most onerous operating conditions.

SCALE RANGE ADJUSTMENT—When the scale range adjustment is properly set a voltage input which produces a scale reading of 10 will produce a scale reading of 1 on the next higher range. No attention need be given to this adjustment except at very infrequent intervals but if some discrepancy is noted the required change in the adjustment should be made as follows: Allow the meter to warm up for five minutes. Connect a source of **pure** sinusoidal ac of any convenient frequency from 100 to 10,000 cps to the input. Adjust this voltage so that the meter reads 10 on any range other than the 100 volt range. Switch to the next higher range. The meter should read 1. If not remove the black button at the side of the case and adjust the exposed control with a screw-driver until the meter reads 1. Switch back to the lower range and check to see that it reads 10. If not readjust the input voltage to 10 and switch back to 1, readjusting with the screw-driver if necessary.

In the past some users of this instrument have misunderstood the purpose of this adjustment and have tried to use it to bring the needle on the meter to 1 on the scale with no voltage applied to the input terminals. The indicating meter, being logarithmic, has no "zero." The normal position of the needle with no voltage applied to the input is against the left-hand stop and off scale. The meter should read only when a voltage within the range of the voltmeter is applied to its input terminals.

SERVICING — Servicing of this instrument by the user is not recommended except for scale range adjustment described on page 8 and except for the renewal of the fuse, pilot light, and tubes. If trouble develops which cannot be corrected by following these instructions, it is recommended that the instrument be returned to us for servicing. **Before returning the instrument please describe the trouble to us by letter** and we shall furnish shipping instructions.

The failure of the pilot light to light after the switch is turned on is an indication of either a blown fuse or a burned-out pilot light. The pilot light may be replaced from the front of the panel by merely unscrewing the red jewel. A three-quarter ampere fuse is mounted on the chassis inside the case. To renew the fuse first disconnect the instrument from the ac power line and after removing the four nickel-plated screws on the panel carefully lift out the panel from the case. The fuse clip is situated alongside the power transformer.

Spare fuses are provided and if additional fuses are required these may be ordered directly from Littelfuse, Inc., 4757 Ravenswood Avenue, Chicago, Illinois. The type number is 8AG, three-quarter ampere.

SPECIAL VERSIONS OF THE MODEL 300 VOLTMETER—

Although the basic Model 300 Voltmeter, used either by itself or in conjunction with its various accessories is a most versatile instrument a number of special versions or modifications of the voltmeter have been created to meet the particular preferences of various industrial and scientific organizations. These special instruments are tabulated below and application should be made to Ballantine Laboratories regarding prices and delivery.

Ballantine Laboratories, Inc., is always ready to consider requests for new custom-built variants of the Model 300 Voltmeter or of any of its other standard products and usually special needs can be satisfied at only a nominal increase of price above that of the basic Model.

MODEL No.	DESCRIPTION
300-S/1	Similar to basic Model 300 but having one megohm input impedance (3% accuracy).
300-S/2	Similar to basic Model 300 but mounted on a 19″ x 7″ x 1/8″ relay rack panel.
300-S/4	Similar to basic Model 300 but covering a voltage range of 2 millivolts to 200 volts.
300-S/5	Similar to basic Model 300 but with the db scale referred to 1 milliwatt in 600 ohms. Range switch marked in db's as well as volts.
300-S/7	A combination of the Model 300-S/1 and Model 300-S/2 deviations from the basic Model 300.
300-S/10	A combination of the Model 300-S/2 and Model 300-S/5 deviations from the basic Model 300.